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Fingerprint Image Enhancement Algorithm Based on Two Dimension EMD and Gabor Filter

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Abstract

Newly acquired fingerprint images have a lot of noise. This article use BEMD decomposes the fingerprint image. Each of the IMF obtained represents a particular scale. To some extent, it reflects the image texture information at different scales. The proposed algorithm use two-dimensional empirical mode decomposition to resolve the fingerprint image into a series of IMF and the residual. Take into account the distribution of noise between each component, the method use selected components to synthesis fingerprint image. It eliminates the effect of noise and enhance fingerprint image effectively.

Keywords EMD; fingerprint images; Gabor filter;

1. Introduction

Newly acquired fingerprint images have a lot of noise. This is mainly caused by usual work environment. Image enhancement is to reduce noise and increase ridge and valley contrast. To get a clear fingerprint image is not an easy thing.

To this end, we use two-dimensional empirical mode decomposition to enhance fingerprint image. In this paper, we firstly extended the one-dimensional EMD algorithm to two-dimensional. We use a fast two-dimensional EMD algorithm to process fingerprint images and eliminate the bad influence of noise on the fingerprint image [1].

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EMD application in two-dimensional signal (such as images) analysis has just started, and has achieved some results. For example, Nunes proposed two-dimensional empirical mode decomposition (Bidimensional Empirical Mode Decomposition BEMD) method for image texture analysis; Linderhed used BEMD in image compression; Liu Zhongxuan proposed the directional EMD and uses it in image segmentation [2]

2. Implementation of BEMD

In the two-dimensional EMD algorithm, the key step is to generate local mean surface for two-dimensional data [3]. This study extends the recently proposed B-spline EMD, and the finite element basis functions is used to replace the previous B-spline to construct the local mean surface. We first get a triangular grid form the local extreme points and saddle points. Then, we construct a triangular mesh on the linear combination of linear function. Coefficient of linear functions is a low-pass filter to the local minimum and saddle point set [4]. This process can be effectively implemented.

Supposing $f \in L^2(R^d)$, we choose a compact support base ϕ_j. The base is adaptive. We use these basic functions to construct the mean surface of a given data. $P := \{p_j : j \in \mathrm{Z}\}$ is a set of feature points. We smooth $f(p_j)$ by $\lambda(p_j) = S *' f(p_j)$.

Where S is a low-pass filter, $*'$ representing the generalized filter operation. We specify a set of positive weights set. The generalized low-pass filter is a weighted sum of adjacent extreme points. Therefore, the production $\lambda(p_j)$ smooth than $f(p_j)$ [5].

We express the local mean surface of our data set f is:

$$m(p) = \sum_{j \in z} \lambda(p_j)\phi_j(p) \qquad m(p) = \sum_{j \in z} \lambda(p_j)\phi_j(p) \tag{1}$$

In the one-dimensional EMD, the local maximum and local minimum is important. In the case of two-dimensional, in addition to the local maximum and minimum values, we also need to consider the saddle point. Because in different directions, which reflect the function of the important characteristics of local change [6]. For this reason, we select three types of feature points, and treat them the same way.

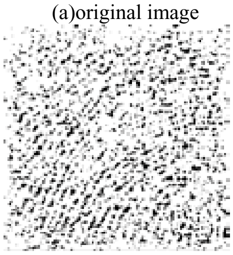
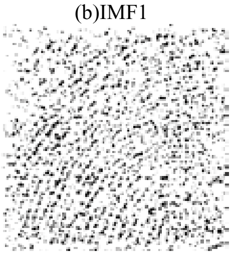
3. Experiments

Figure 1 is the decomposition image of the IMF for the sample fingerprint obtained by two-dimensional EMD. We found that the noise contained in the high frequency IMF is relatively less, while contours of the low frequency IMF are fuzzy. By two-dimensional EMD decomposition, we can isolate the intrinsic component of the fingerprint image and noise components.

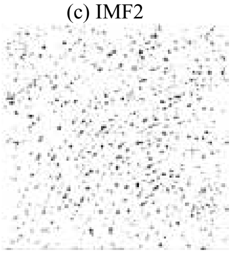
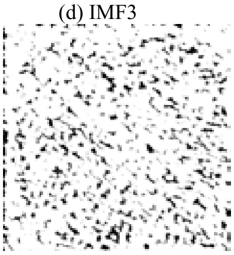
Figure 1 (a) is the original fingerprint image, the other are IMF component in the order of decreasing frequency. In order to overall assessment the algorithm. We have done a lot of experiments on the fingerprint library FVC2002.

Figure.2 shows one set of the experiment results. Experiment results show that the algorithm can achieve satisfactory enhancement. It is a simple and effective algorithm for fingerprint image enhancement. Figure.2 (a) is the original fingerprint image. Figure.2 (b) is the result of synthetic fingerprints image by high-frequency IMF after two-dimensional EMD decomposed. It can be seen that the effect of noise has been greatly reduced, Figure.2 (c) is the enhancement effect of the Gabor filter, and we have segmented and normalized the enhanced fingerprint image based on the quality of the image.

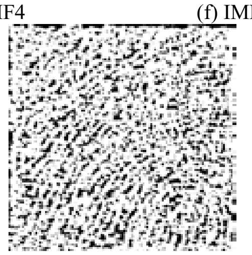

(a)original image (b)IMF1

(c) IMF2 (d) IMF3

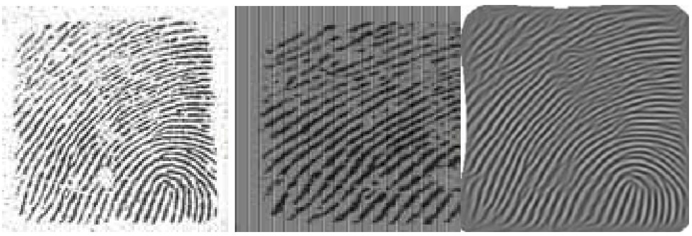



(e) IMF4 (f) IMF5



(g) Residual

Figure 1 fingerprint image and the IMF



(a) Original image (b) synthesized fingerprint（c）the final fingerprint image g

Figure 2 fingerprint image and the enhanced image

After analysis the fingerprint image texture, we found the fact that the fingerprint image is a quite regular two-dimensional sinusoidal surface. Therefore, in terms of fingerprint images, the Gabor filter can effectively filter out the noise and repair the fingerprint ridge reasonably. Original fingerprint image contains a lot of noise. The noise has an effect on the calculation of fingerprint image direction and frequency. We decompose the fingerprint image by two-dimensional EMD and use the high frequency IMF components to synthetic fingerprints. Our method can avoid the noise's impact on the follow-up process. The results show that compared to only using Gabor filters, our algorithm can effectively improve the practical performance of the fingerprint image enhancement. So it greatly improves the fingerprint minutiae extraction accuracy.

Fingerprint image enhancement provides a basis for the fingerprint matching algorithm [7]. Minutiae refer to the end and the bifurcation point of ridge. To evaluate fingerprint enhancement performance, we can comparison the number of extracted feature points from the enhanced fingerprint image and the original image. We select ten low quality fingerprint image from the FVC2002 database to extract feature using the same extraction method after enhanced and before enhanced. The results were compared and listed in table 1.

Table 1 algorithm compared with the traditional algorithm

a	b	c	d	e
1	17	8	9	3
2	16	9	10	2
3	19	7	5	3
4	12	8	13	1
5	11	11	8	2
6	14	8	8	4
7	15	9	4	3
8	16	5	11	1
9	12	7	8	3
10	18	3	4	2

In table 1, Column (b) show the number of loss minutiae after enhance by the traditional algorithm; Column (c) show the number of loss minutiae after enhance by our algorithm; Column (d) show the number of error minutiae after enhance by the traditional algorithm; Column (e) show the number of error minutiae after enhance by our algorithm. From the experimental results, it can be seen that the performance of our algorithm is improved than the traditional algorithm

4. Conclusions

In this paper, we decompose the fingerprint image by BEMD algorithm. Each of the IMF obtained represents a particular scale. They reflect the image texture information at different scales. In order to improve noise removal and thereby enhance the fingerprint image, we apply the EMD technique to process fingerprint image. The comparison with traditional algorithm demonstrated that our method can produce superior results.

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